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TECHNOLOGY DIVISION

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Power Equipment Lubrication in Commercial Buildings

Part I

Power Generating Apparatus

PUBLISHED MONTHLY BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICANTS

For Commercial Building Power Plants

Steam Reciprocating Equipment

Steam Cylinders:

For Superheated Steam Conditions	TEXACO 650 T CYLINDER OIL OR TEXACO LEADER CYLINDER OIL
For Saturated Steam (*above 150 lbs. pressure where economy in use is possible*)	TEXACO 650 T CYLINDER OIL OR TEXACO LEADER CYLINDER OIL
For Saturated Steam (*below 150 lbs. pressure where conditions of feed are good*)	TEXACO PINNACLE CYLINDER OIL
Where Atomization Conditions are Poor or Rapid Separation from Exhaust Steam is Necessary.	TEXACO VANGUARD CYLINDER OIL
Where Condensed Steam is to be Returned to Boiler (*for the manufacture of Ice, or in other process work*)	TEXACO VANGUARD MINERAL CYL. OIL TEXACO VANGUARD CYLINDER OIL OR TEXACO PINNACLE MINERAL CYL. OIL
Where Rapid Atomization is Necessary (*Medium Steam Pressures and Moisture Conditions Involved, and Oil Feeds are Close to Steam Chest, etc.*)	TEXACO OLYMPIAN CYLINDER OIL
For Low Pressure Wet Steam Conditions	TEXACO DRACO CYLINDER OIL

External Bearing Lubrication:

Sight Feed Oil Cups	TEXACO TEXOL OIL C OR D OR TEXACO ALEPH OR ALTAIR OIL
Grease Lubrication	TEXACO CUP GREASE No. 1 or No. 3
Circulating Systems (*normal conditions*)	TEXACO TEXOL OIL B OR C OR TEXACO NABOB OIL
(*under adverse water conditions*)	TEXACO REGAL OILS
Crankcase and Splash Oiling Systems (*normal conditions*)	TEXACO CANOPUS OIL
(*under adverse water conditions*)	TEXACO REGAL OILS

Steam Turbines

Ring Oiled Bearings (*normal temperatures*)	TEXACO CANOPUS OIL OR TEXACO REGAL OILS
(*where temperatures are exceedingly high*)	TEXACO 621 OIL
Circulating Oiling Systems (*direct drive*)	TEXACO REGAL OIL A or B
(*reduction geared*)	TEXACO REGAL OIL C
(*reduction geared, abnormal conditions*)	TEXACO REGAL OIL E

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Coal Pulverizers, Electric Motors, Blowers, Fans, Rotary and Screw Pumps, Boiler Tube Cleaners

Ring or Chain Oilers:

Normal Temperatures	TEXACO REGAL OIL B OR TEXACO CANOPUS OIL
Low Temperatures	TEXACO CETUS OIL OR TEXACO CAPELLA OIL
High Temperatures	TEXACO ALCAID OIL TEXACO ALGOL OIL OR TEXACO TEXOL OILS C OR E

Plain Bearings:

Sight Feed Oil Cups, etc.	TEXACO TEXOL OIL C OR D OR TEXACO ALEPH OR ALTAIR OIL
Grease Lubricated	TEXACO CUP GREASE No. 1 or No. 3

Ball and Roller Bearings:

(Oil Lubricated)

Where housings are oil-tight, operating conditions normal and speeds high	TEXACO SPICA OIL OR TEXACO CETUS OIL
For Roller Bearings where end thrust is appreciable; and Ball Bearings under low speeds and higher temperatures	TEXACO ALCAID OIL TEXACO ALGOL OIL TEXACO URSA OIL OR TEXACO TEXOL OILS
For Roller Bearings operating under extreme temperature and pressure	TEXACO PINNACLE MINERAL CYLINDER OIL

Ball and Roller Bearings:

(Grease Lubricated)

According to type and construction of the bearing, and operating pressures and temperatures	TEXACO STAR GREASE OR TEXACO MARFAK GREASE

(*Continued on Inside Back Cover*)

LUBRICATION

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Power Equipment Lubrication in Commercial Buildings

POWER requirements in the modern office building, department store, hotel, post office, etc., are extensive and decidedly variable. To serve the public is the aim of the management. A difficult problem as a rule for the whims of the public are as changeable as the winds. Today it is more heat, tomorrow more light; or perhaps the elevator service comes in for its share of the overload.

All of which renders the matter of peak loads most difficult to anticipate in commercial building power consumption.

From this viewpoint of economy, larger sized commercial buildings have found it desirable to generate their own power. Steam in fact, is practically always an essential for heating purposes. With steam available it is usually but a step further to install electric generating equipment and operate independently of the municipal power station. That this is a desirable procedure is indicated by the extensive number of individual power plants in modern department store and office building service.

EQUIPMENT INVOLVED

As a general rule the average commercial building power plant will involve the following equipment or certain combinations thereof, according to power requirements, the size of the plant and the type of fuel available, i.e.:

Steam Engines
Steam Turbines
Automatic Coal Pulverizers
Automatic Stokers
Boiler Tube Cleaners
Electric Motors, Blowers, Fans
Feed Water and Fuel Oil Pumps.

In addition, other equipment requiring lubrication will involve

Refrigerating Compressors
Air Compressors
Electric Elevators
Sidewalk Hoists
Escalators, and
Speed Reducers.

PART I

Reciprocating Steam Driven Equipment

Steam Cylinder Lubrication

Lubrication of such equipment as reciprocating pumps, engines, etc., can be broadly classified as internal and external, i. e., as applying to:

(a) steam cylinders and valve chests, and—

(b) to bearings, pins and guides.

In a discussion of steam cylinder lubrication, steam pressure, temperature, and moisture conditions, engine design and construction, and operating speed must be considered. We can

usually attain best results by regarding the above from the viewpoints of:

1. The parts to be lubricated.
2. How the oil must be applied.
3. The operating conditions involved.
4. How to select the most suitable oil.
5. How to determine if lubrication is effective.

What the Oil Must Lubricate

The function of a steam cylinder oil is to lubricate every sliding surface which is either in direct contact with the steam, or subject to its pressure and temperature. Therefore valves, valve rods, valve seats, cylinder walls, pistons and piston rods are involved. These parts are not always subject to the same pressure and temperature conditions, yet the one oil must serve throughout, and therefore be sufficiently flexible in operation to produce efficient lubrication at all times.

There are, in general, four types of steam valves, i.e., the slide or D-valve, the piston valve, the Corliss and the poppet valve. Of these, the common slide valve is the most difficult to lubricate due to inequalities of pressure and the consequent "wiping" action it exerts upon the lubricated valve seat. Therefore the oil film must be continuously renewed.

With the piston valve, on the other hand, the steam pressure is balanced, and as a result there is less tendency for the oil to be squeezed or wiped from the valve seat. As a result, piston valve engines can operate under considerably higher pressures than slide or Corliss valve engines.

The Corliss valve is a slide valve to the extent that it is subject to a sliding action on its curved seat. There is not as great an area of contact, however, hence, although it is subject to unbalanced steam pressures, this type of valve can carry higher pressures than a plain D-valve. The chief difficulty with a Corliss valve is to maintain a suitable film of lubricant at the end of the valve. Therefore individual feeders for the lubricant are usually installed at such points.

Poppet valves while reciprocating in action are not subject to sliding on the valve seat. Valves of this type are balanced as to steam pressure; hence they are capable of operating under higher pressures the same as piston valves. They are extensively used in certain types of uniflow engines.

Poppet valves require lubrication of stems only. It is essential to regulate the flow of lubricant carefully and to guard against an excess, otherwise abnormal carbonization of the oil will occur and the valves may stick.

Valve and piston rods, in turn, require quite as efficient lubrication as valve seats and cylinder walls if they are to operate effectively. It is usually considered the duty of a cylinder oil to lubricate these latter and in general, they will receive sufficient lubrication from the oil in the steam.

In certain cases, however, it may be advisable to install either auxiliary sight feed oil cups or make some other provision for oiling the rods externally at regular intervals. These parts are very accurately machined and adjusted; and often metallic packing is used, therefore any overheating due to lack of lubrication might affect the packing or cause a change in alignment, with ultimate damage to the internal mechanism of the engine.

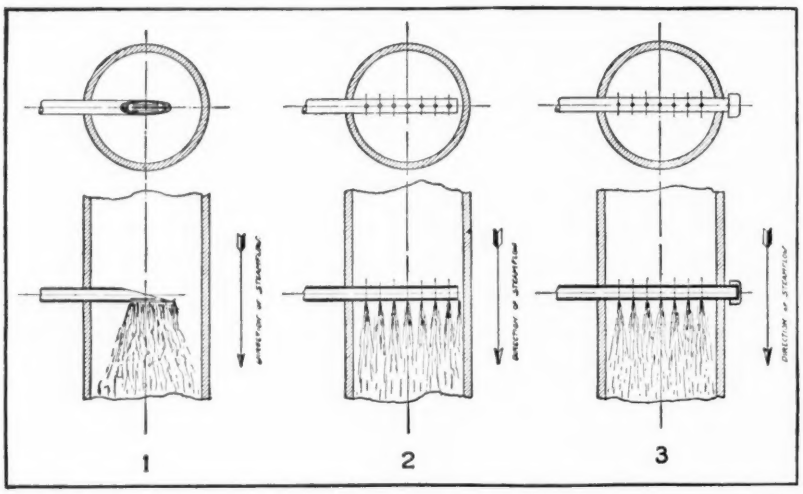


Fig. 1—The spoon-shaped atomizer. This is an exceedingly satisfactory type of atomizer serving to break up the oil effectively.

Fig. 2—The perforated type of atomizer which makes use of a number of perforations in the nipple through which steam is able to pass, thereby carrying oil out with it in the form of spray.

Fig. 3—Another type of perforated atomizer which is extended through the steam pipe and capped at the outer end. Cleaning out is thereby materially facilitated. Some engineers prefer to use a valve instead of a cap at this end to permit blowing out with steam with the least amount of trouble.

Method of Application of the Lubricant

Having reviewed the parts under steam pressure requiring lubrication, we are next concerned with the application of the lubricant.

LUBRICATION

Lubrication is effected by either one or two methods:

(1) The application of oil directly to each of the separate wearing surfaces, or—

(2) Delivery of the oil into the steam line, the steam serving to atomize it and carry it to all moving parts within the valve chest and cylinder.

Direct application of steam cylinder oils by means of individual oilers installed on the valve chest and cylinder is the more crude and uncertain of the two methods. Here the lubricant is fed drop by drop into the engine, being spread over the wearing surfaces by the movement of the valve and piston.

As a result steam cylinder lubrication by means of injecting oil into the steam line, using a hydrostatic or mechanical force feed lubricator, is regarded as far more dependable and conducive to increased efficiency.

The fact that the steam reaches practically all of the surfaces requiring lubrication, in its passage through the engine insures the transmission of the particles of oil which it carries, to these parts. However, sufficient oil must be fed to the steam line and the point of introduction of the lubricant must be located at a suitable distance beyond the throttle valve and the steam chest to enable the steam to completely exercise its atomizing effect. Oftentimes this procedure is spoken of as "lubricating the steam."

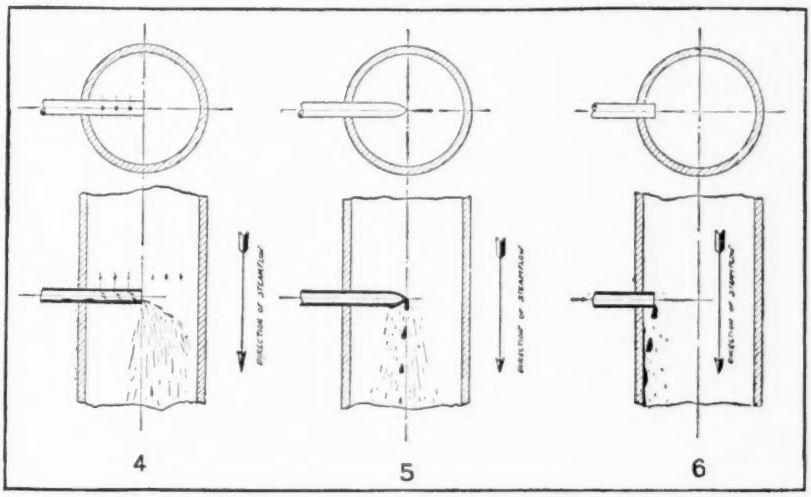


Fig. 4—The perforated atomizer can also be constructed with holes on the top side only, the steam making two right-angular turns as shown. Oil is claimed to be effectively atomized by this procedure.

Fig. 5—A drip type of atomizer in which the end within the steam line is drawn down to form an orifice.

Fig. 6—In this type of installation the extent to which atomization may occur is questionable. The further in toward the center of the steam pipe that the nipple extends, the more chance will there be for the oil drops to be broken up by the action of the steam.

Complete atomization is the secret of steam cylinder lubrication. If any of the oil is carried into the cylinder in liquid state its lubricating effect is lost, as it will either be swept out prematurely by the rush of exhaust steam, or not be able to distribute itself uniformly over the wearing surfaces.

If the point of introduction is located too close to the throttle valve or cylinder, complete atomization may not take place; if too far away there will be possibility of the oil particles being thrown to the walls of the steam line, from whence a flow of liquid lubricant will occur to the valve chest. In effect this might well be termed condensation of the lubricant, and it will be quite considerable if there are any bends or other pipe fittings located between the lubricator and the valve chest.

Automatic lubrication will usually be adaptable to the average commercial building steam engine. We are therefore concerned with two types of lubricators, i.e.—

(1) The hydrostatic and

(2) the mechanical force feed type.

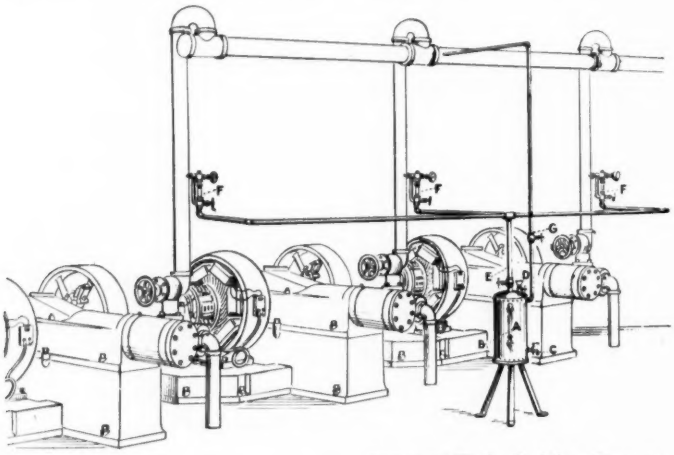
Hydrostatic Lubrication

The hydrostatic lubricator embodies the principle of forcing the oil drop by drop into the system by means of a head of water which is maintained by condensing of the steam. A hydrostatic installation cannot be depended upon to be absolutely positive due to the more or less erratic nature of the conditions to which it is subject. For example, a change in temperature will affect the viscosity of the oil, the size of the globules fed, and consequently the regularity of the flow. In addition, the flow of oil will be independent of the speed of the engine.

Force Feed Lubricators

The mechanical force feed lubricator more or less overcomes certain of these objections by virtue of the fact that it is connected directly to some reciprocating part of the engine. Consequently oil is fed into the system at a rate which varies directly with the speed. Such a lubricator functions only when the engine is operating, hence there is little possibility of wasted oil or flooding of the system. An efficient mechanical lubricator should feed the

same amount of oil regardless of the temperature, viscosity or amount of oil in the reservoir. In general, while a device of this nature can be used with either a direct feed or an atomizing spoon, the spoon is more commonly used.



Courtesy of The Lunkenheimer Company

Fig. 7—Central tank multiple feed, hydrostatic lubricating system:
"A" is the oil storage reservoir.
"F" the respective lubricators.

Operating Conditions Involved

The operating conditions that a cylinder oil will have to meet are: steam pressure, temperature, velocity, moisture in the steam, degree of superheat, priming, foaming, boiler compounds, and the use (if any) which is to be made of the exhaust steam.

Steam pressure alone has but little influence upon a cylinder oil. The temperature associated with the pressure, however, as well as the degree of superheat to which the steam may be subject, has a very marked effect.

This must be taken into consideration when selecting the cylinder oil due to its more or less effect upon the viscosity of the oil film on the cylinder walls and valve seat. Viscosity will be decreased accordingly as steam temperatures are increased. Therefore, where operating with high temperature saturated or superheated steam a heavier bodied oil should be used.

Steam temperature and velocity affect the atomization of the cylinder oil to a marked extent. Thus, the higher the temperature and velocity the more readily will a heavy bodied oil be atomized, due to the reduction in viscosity which occurs at the temperature of atomization.

From the viewpoint of the actual composition of a cylinder oil, the question of moisture in the steam is the most important factor involved. Moisture will usually result in a film of straight mineral lubricating oil being rapidly washed off from the cylinder walls and other surfaces with which the steam comes in contact. Therefore, to secure proper lubrication under wet steam conditions it is necessary to use an oil which contains a certain percentage of fatty compound such as lard oil, degras, or tallow.

Where a compounded oil is used an emulsion is developed by the moisture in the steam reacting with the fatty component. The lubricating film thus has a greater affinity for the cylinder walls and other wearing surfaces and becomes highly resistant to the washing action of the water in the steam. The greater the percentage of moisture in the steam the higher should be the fatty compound content of the lubricant. In general the compound should not exceed 10%.

Where the exhaust steam is to be used for feed water heating, it is important to observe caution in selecting and using steam cylinder lubricants. If efficient oil separators are installed usually the greater percentage of any oil carried over by the exhaust steam will be removed. If, however, separation is not practically complete, oil deposits may result in the heaters or on the boiler tubes. Damage to the latter may occur ultimately due to uneven heating and blistering, etc.

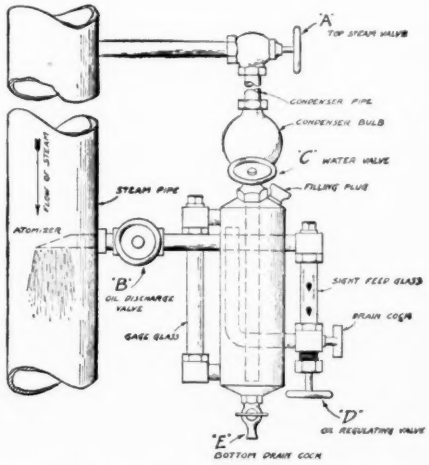


Fig. 8—Line sketch of a typical double connection type of hydrostatic steam cylinder lubricator, showing essential features of construction and means for adjustment, etc.

Selection of Steam Cylinder Oils

Operating conditions, etc., are the controlling factors in the selection of any steam cylinder lubricant. For this reason the essential features influencing the selection of such products have been covered above.

The Determination of Effective Lubrication

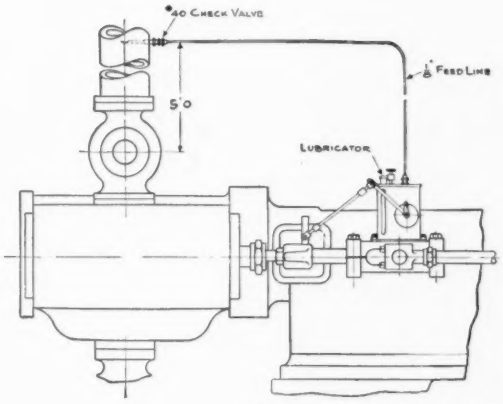
In general the real test of a cylinder oil should be the condition of the wearing surfaces upon which it is used. Therefore, hasty decision as to the suitability of such an oil should be guarded against, as time is necessary for the lubricating film to form and function properly. Any test should, therefore, cover a period of several weeks.

The engine should then be shut down, and the cylinder head and valve chest cover removed and the interior examined. If upon immediate inspection the wearing surfaces show a film of lubricant sufficient to give a brownish stain through three or four thicknesses of cigarette paper, they are sufficiently lubricated. If below this film they appear highly polished and of a color varying from bright iron-white to steel-blue, they have been properly lubricated.

Where the surfaces are rough, dry, dull in appearance or rusty, lubrication has either been insufficient or the wrong grade of oil has been used. In addition, if the stain on the cigarette papers appears streaked, blackish or mottled, either the oil has been subject to carbonization or abnormal wear has taken place. Excessive lubrication, on the other hand, will be indicated by pools of oil lying in the bottom of the cylinder or in the counterbore.

Under operation the efficiency of lubrication can be roughly judged by:

1. The film of oil on the piston rod.
2. The amount of oil in the condensate.
3. The action of the valves.



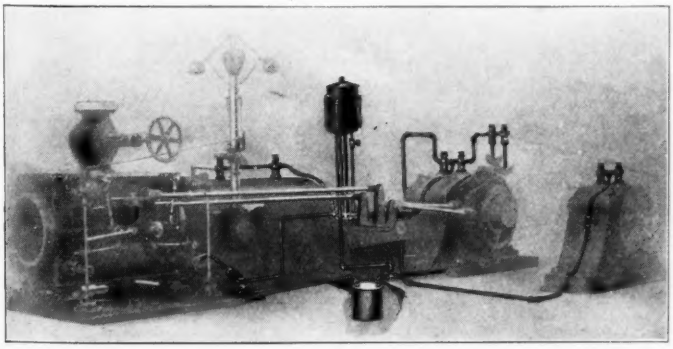
Courtesy of S. F. Bowser & Co., Inc.

Fig. 9—Method of mounting a mechanical lubricator for steam cylinder lubrication on a high speed engine. Note drive connection from valve rod.

A suitable film on the piston rod (unless oil is fed directly to it), minute drops of oil and a milky appearance in the condensate, free action, and little or no noise in valve operation, are indications that the oil is suitable, atomization complete, and the rate of feeding correct.

Lubrication of External Reciprocating Elements

Bearings, guides and pins of reciprocating engines, compressors, and steam pumps are, in general, lubricated by sight feed oil cups or grease cups; or some form of continuous lubrication.



Courtesy of S. F. Bowser & Co., Inc.

Fig. 10—Showing details of piping necessary in an individual oiling and filtering system on a simple Corliss engine.

Intermittent Lubrication

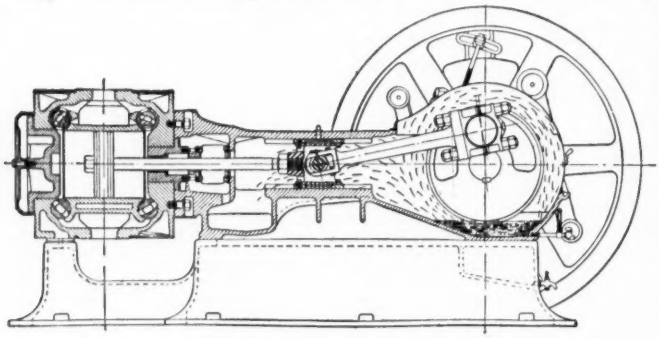
Oil and grease cups involve intermittent lubrication. In general they are simple in operation, and if properly adjusted will feed the right amount of lubricant to afford sufficient lubrication with decided economy. However, the tendency is oftentimes to neglect such equipment with the result that considerable direct waste occurs.

Sight feed oil cups require a medium to heavy oil which should be selected for its ability to remain on the bearing surfaces for fairly lengthy periods. As a general rule systems of this nature will require an oil of from 300 to 500 seconds Saybolt viscosity at 100°F. Oftentimes operators will have a tendency to use an oil of somewhat higher viscosity in order to compensate for wear. This, however, is not good practice inasmuch as higher viscosities give rise to abnormal heating and power consumption.

Continuous Lubrication

Continuous lubrication involves a directly opposite theory to intermittent lubrication inasmuch as the bearings are literally flooded with an excess of oil over that which is abso-

lutely requisite for proper lubrication. The function of the oil is therefore to act not only as a lubricant but also as a cooling medium to carry off any frictional heat that may be developed in the bearing under operation.



Courtesy of Industrial Oil Engineering. By J. R. Battle.

Fig. 11—Cross-section of a Corliss engine showing splash lubrication of external parts.

This flood of lubricant also keeps the bearing surfaces free from dust, dirt and metallic particles, and thereby reduces the tendency towards abnormal wear, scoring, etc.

In certain installations the oil from a continuous oiling system can be drained to some central point of collection such as the base of the engine from which it may be removed when desired, and filtered or centrifuged in order to effect purification.

Continuous oiling may be broadly grouped into two classifications, i.e.:

1. Splash lubrication, and
2. Force feed lubrication.

Splash Systems

Splash lubrication is adaptable to engines where the crankcase is completely enclosed and the entire system oil tight. In general splash systems have some provision installed on the crank for picking up the oil from the base of the machine and transmitting or throwing it to the points to be lubricated.

The essential idea in splash lubrication is to maintain a suitable supply of oil in the crankcase in order that the crank or its oil dipper will never miss the surface of the oil.

In equipment lubricated by splash systems a quick water and sediment separation is imperative. The viscosity of the oil in a splash system should, therefore, be as low as is consistent with requirements, in order to insure rapid precipitation.

Few lubricants receive any harder service than those involved in systems of this type, since they are used over and over again without purifying or external cooling.

Force Feed Lubrication

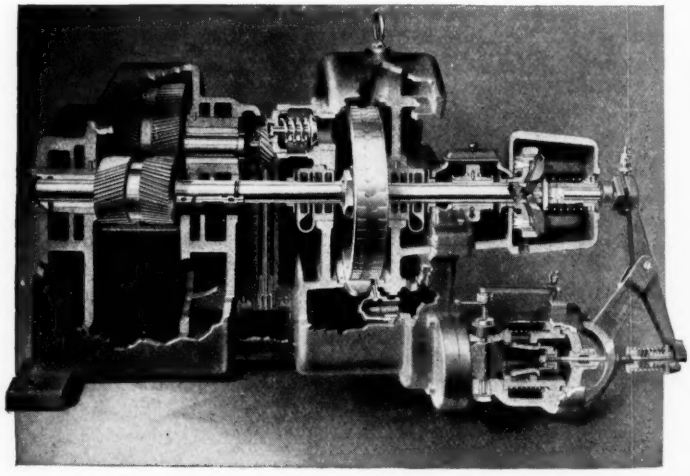
In a force feed system the oil is forced into the bearings at pressures ranging from 5 to 15 lbs. per square inch. This may be obtained either by making use of the action of gravity or employing oil pumps.

Where the first is involved suitable storage tanks are located at a sufficient elevation above the bearings to produce a head corresponding to the required pressure.

In the second case an oil pump is installed, the oil being passed in a continuous cycle through the bearings, and then filtered and cooled, etc.

Lubricants used in a force feed system have their requirements controlled to a large extent by operating and constructional conditions. When the system includes ample purifying and circulating capacities the oil will be subject to comparatively light duty, inasmuch as bearings are continually washed out and there is opportunity for dirt and water to precipitate. Also, as there is an adequate and continuous flow of lubricant it will be generally unnecessary in such a case to select an oil capable of standing extreme temperatures or loads.

It must be remembered that the lighter the oil the lower its internal friction will be. In fact the two essential requirements are that the oil shall not emulsify nor contain any corrosive acids. Emulsification would clog the system, while acids would cause deterioration



Courtesy of The Terry Steam Turbine Company.

Fig. 12—Cut-away view of a combined turbine and gear unit with the turbine and gear casing cast integral. Relation of gears, bearings and other essential parts is clearly shown. Note the three-point (or bearing) support.

of the piping, filters, settling tanks, bearings, etc. A pure mineral oil of from 150 to 200 seconds Saybolt at 100°F. will be usually satisfactory for such service.

Ring and chain oilers are also used to a certain extent in power plant service, and involve flood lubrication within the ability of the rings or chains to transmit the oil to the bearing. The same conditions hold for lubricants for this type of service as have been mentioned under splash lubrication. More detailed discussion will follow.

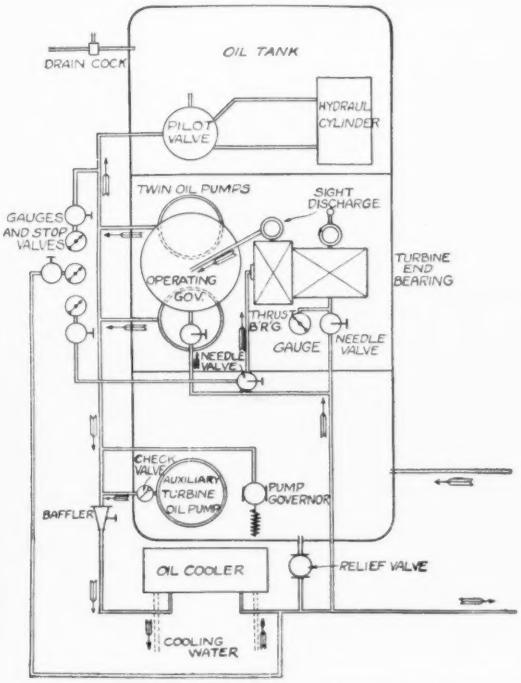
Essential Requirements

The selection of engine lubricants depends largely, as has been seen, upon the method of application. In general, however, there are certain definite requirements which the oil must possess, such as:

1. Sufficient body or viscosity to prevent metal-to-metal contact of the surfaces to which it is applied, but not so heavy as to produce high internal friction.
2. An ability to flow readily when low service temperatures are involved.
3. A flash point sufficiently high to indicate that a reasonable factor of safety has been provided, and that loss due to evaporation will be low.
4. Ability to stand up under continued service without any excessive tendency towards decomposition or gumming.
5. Ability to meet special service requirements such as quick water separation, a low degree vaporization, and the least tendency towards emulsification.
6. Freedom from impurities which might prove injurious to the system.

The Steam Turbine

Steam turbine service imposes perhaps a more exacting task upon the lubricant than any other type of power plant machine operation. High rotating speeds over extended periods of time, and extremely small clearances between the bearings and journals, require a constant and positive supply of oil which is capable not only of resisting admixture with foreign matter such as water, dust, sludge, etc. but also of maintaining an operating viscosity such that the lubricant will readily circulate to the entire bearing and show a minimum of internal friction.



Courtesy of General Electric Company.

Fig. 13—Diagram of the lubricating system for a Curtis steam turbine.

Factors Affecting Oil Selection

In general the selection of turbine lubricants will be affected to a more or less extent by:

1. The rotational speed.
2. The size of the bearings, and
3. The clearance space.

Speed of Rotation

Speed of rotation is of importance in that it directly affects the amount of oil which will be drawn through the bearing clearance space. A film of oil is practically always present upon the revolving surface of a properly lubricated journal. Thus, due to the inherent viscosity of the oil, the layers adjacent to that adhering to the metal will be drawn into the clearance space. But their entry will be resisted by the oil already therein which in turn is more or less squeezed out by the weight of the bearing.

This latter force is relatively constant, varying only according to the size and weight of the journal. On the other hand, the force of attraction which tends to draw the oil into the clearance space is variable, and directly dependent upon the rubbing speed and viscosity of the oil. Therefore at high rubbing or rotational speeds it is evident that an oil of somewhat lower viscosity will be required to maintain a suitable film in counteraction to the force of expulsion due to the weight of the journal.

The Size of the Bearing

The size of the bearing enters into the question in that it involves the weight and operating pressure to which the oil film in the clearance space is subjected.

Clearance Space

The clearance space is of importance in that it directly governs the maintenance of the oil film. That is, the greater the clearance and the more accurately this is expanded (or the bearing edges chamferred) at the point of entrance of the oil, the more readily will the revolving journal draw a suitable film of lubricant through the bearing. By expanding or chamferring, as above, the formation of a wedge of oil is made possible, the oil entering at the base or thicker part of this wedge, and passing into the clearance at the point.

Indicating Characteristics

In connection with the above, there are certain characteristics pertinent to the oil which must also be studied. In other words, the viscosity, cooling effect of the oil, its evaporative tendency, and the tendency towards decomposition, emulsification, and sludge formation are all of distinct importance.

Viscosity and Fluid Friction

The function of fluid friction according to the theory of lubrication is to eliminate metallic or solid friction by the substitution of the fluid friction of an oil film. Therefore, we have to deal with the friction which arises when particles or films of oil move or slide past each other.

Viscosity is a controlling element in this regard, since it resists this change in the relative position of the oil particles, or the sliding of adjacent films over one another.

Frictional losses can never be entirely eliminated, and a certain amount of power must always be used to overcome fluid friction. As we decrease viscosity, however, within reasonable limits, fluid friction can be reduced, but it is never safe to carry this too far as it is very possible to reach a point where the oil will be so light in body as to be unable to support the weight of the bearing or resist operating pressures.

Cooling Effect

One of the chief functions of a turbine oil is to carry away to as great an extent as possible, the heat generated during operation. If this is not brought about, the viscosity and hence the supporting ability of the oil, will drop to a certain extent, oftentimes even to such a degree as to render the oil incapable of keeping the metallic surfaces apart. So it is customary in larger turbines to flood the bearings with oil under a certain uniform pressure to insure both lubrication and cooling.

The cycle of operation is made complete by the draining of this lubricant back into a suitable sump tank where it is cooled, and in many systems subjected to more or less purification before re-using. In general, operating temperatures will depend upon the design of the bearings, the viscosity of the oil and the volume in circulation.

Courtesy of The Griscom-Russell Company.

Fig. 14—A turbine lubricating oil cooler of the Multi-whirl type. In this cooler the oil is pumped through the shell, the cooling water being passed through the tubes.

Evaporative Tendency

Any petroleum oil when subjected to churning or agitation in the presence of air will evaporate to a certain extent, depending, naturally, upon its characteristics. Although the average turbine oiling system is generally tightly enclosed and built to operate as free from oil leakage as possible, a certain amount of foaming may occur to result in subsequent loss of oil, especially under higher operating temperatures. As a result, the remaining oil will gradually tend to increase in viscosity. However, the more highly refined an oil, the lower evaporation will it show under continued operation.

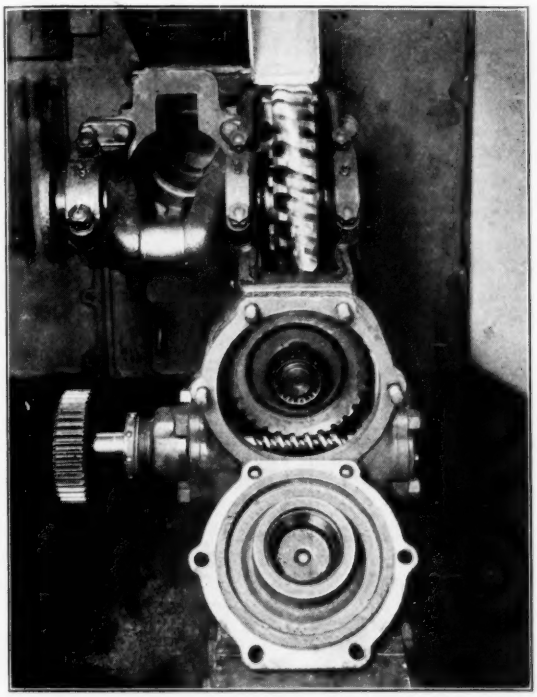
Decomposition, Emulsification and Sludge Formation

The above are inter-related to a certain extent. They are, therefore, considered collectively. Decomposition and oxidation of turbine lubricants are not only most objectionable features from an operating viewpoint, but also the most prevalent effects of high bearing temperatures.

However carefully refined a turbine oil may be, a certain amount of oxidation and decomposition will take place if it is subjected to abnormally high temperatures in the presence of air. Such reactions are indicated by a darkening in the color of the oil. From a lubricating point of view change in color alone has yet to be proved a detrimental feature.

It is known, however, that this gradual decomposition and oxidation of turbine oils may result in the formation of sludges. These, when agitated with water may give rise to gumming and emulsification. The more highly re-

fined the oil, however, the more rapidly will it separate from water. It is generally admitted that water cannot be kept out of a turbine lubricating system, there being so many possible sources of entry such as leaky cooling coils



Courtesy of Riley Stoker Corporation.

Fig. 15—Exposed view of the mechanical drive on the Jones Side Dump stoker. Note tightness of gear housings, and provision for high pressure grease lubrication of bearings.

or water jackets, condensation, moist air drawn into the system, steam leaks via the stuffing boxes, etc.

The only alternative, therefore, is, first: to select only the most highly refined, pure mineral lubricant, and second: to so design the system that every possible means will be available for the removal of water and sludge from the oil.

If the system is inadequate for the service, or, in other words, if too rapid circulation of the oil is necessary, any entrained water and sludge will not have sufficient time to settle out, and the resultant continued agitation of any oxidized constituents will promote abnormal emulsification, thickening of the oil, the retention of abrasive particles, and ultimate clogging of the oil piping.

In general it may be stated that, given two oils of like quality, the one having the lower viscosity and specific gravity will show a readier separation from water.

It is therefore evident that owing to the high speeds at which turbines are operated, the importance of the selection of proper lubricants can not be over-emphasized. In other words, a turbine lubricant should be a high grade filtered pure mineral product, free from acid, able to separate quickly from water, sludge or other foreign matter, showing the least tendency towards emulsification and with as low a viscosity as possible commensurate with the operating and constructional conditions involved.

Systems of Lubrication

Turbine bearings may be either lubricated by ring oilers or some form of self-contained force feed circulating system. As a general rule the former are not adaptable to machines above 300 H.P. in capacity. For ring oil lubrication the viscosity of the oil will depend upon the extent of heating from external sources and the capacity of the oil reservoir, as well as the extent to which the oil may be cooled by radiation. Ordinarily an oil having a viscosity of approximately 145 to 200 seconds Saybolt at 100° F. will be suitable for such service. On the other hand abnormal temperature conditions may sometimes require an oil of greater body.

Pressure Lubrication

Force feed lubrication involves the supplying of a positive flow of oil to all bearings under a definite pressure; it is used on practically all larger installations. Owing to the fact that constant pressure insures comparatively flood lubrication the viscosity of the oil can usually be maintained within low limits. In systems of this type an oil having a viscosity of from 145 to 200 seconds Saybolt at 100° F. will usually give desirable results.

Geared Systems

When reduction geared apparatus is involved the same oil is generally used to lubricate the bearings and gears. As a result we must select an oil suitable for the heavier duty, i.e., the lubrication of the gears, and yet not be too heavy at the operating temperatures to satisfactorily serve the bearings.

Turbine bearings will seldom require an oil higher in viscosity than 200 seconds Saybolt at 100° F. However, when the oil is used for both bearings and gears on stationary equipment, the viscosity should not be lower than approximately 300 seconds.

On the other hand, the viscosity will depend almost entirely upon the amount of vibration which occurs between the gears. Where this is excessive it may often be necessary to select an oil as high as 500 seconds in viscosity.

It is never advisable on reduction gear installations to use an oil of any higher viscosity

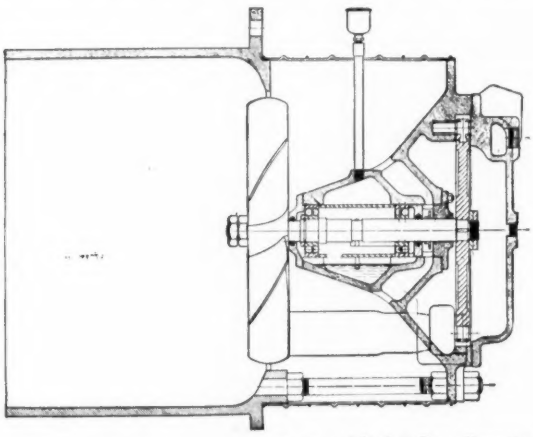
than absolutely necessary, owing to the inability of heavier oils to separate readily from water, and the danger of abnormal internal friction occurring in the lubricant with consequent overheating of the bearings.

Where heavier oils must be used the bearing clearances should be increased in proportion to the viscosity; otherwise the pressure in the oiling system should be raised to a certain extent.

Lubrication of Rotary Bearing Equipment

Coal Pulverizers, Electric Motors, Blowers, Fans, Rotary, Screw and Centrifugal Pumps, Etc.

Lubrication as involved in the operation of the equipment listed above, is essentially a matter of serving their bearings with the proper grades of oil or grease according to their design and the provisions for applying the lubricants.



Courtesy of Buffalo Forge Company.

Fig. 16—Sectional view of a turbo undergrate blower. Note the large oil reservoir, the ball bearings and length of sleeve or housing.

On much of this equipment, ring oilers or anti-friction bearings will be used. To appreciate their lubricating requirements a brief insight into their construction, etc., will be of interest.

Ring Oilers

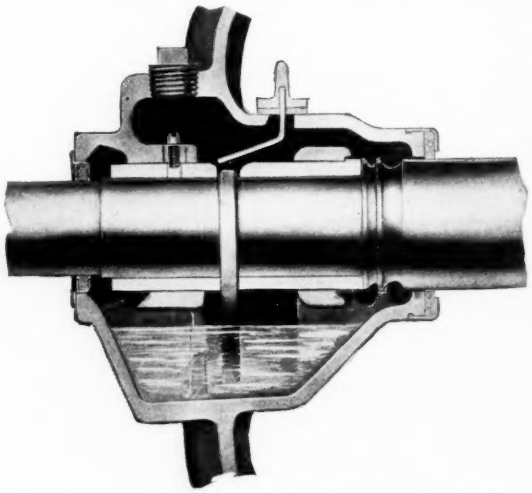
The ring oiler involves a bearing housing which is built with an oil reservoir in the base and a slot of sufficient width and depth to permit one or more rings (according to the length of the bearing) to revolve therein.

As the shaft revolves a rotative motion is given to the latter, to result in a certain amount of oil being carried to the top of the shaft from whence it is able to flow into the bearing oil grooves and clearance space, to be ultimately distributed to the entire wearing surfaces. The extent of dipping of a ring will depend upon the level at which the oil is carried. Usually this is fixed by a suitable sight gage and overflow.

In order to insure effective lubrication by a ring oiler it is important that the reservoir be of adequate capacity to give the oil ample opportunity to rest, thereby making possible not only the settling out of sediment and other foreign matter, but also cooling to the requisite degree. As a rule the only way in which the oil in such a system is kept at the proper temperature is by radiation of heat from the exterior surfaces of the reservoir or well.

In event of this latter being of apparently insufficient capacity, at times it is possible to overcome this by fitting an auxiliary reservoir below the one in question. One way in which this can be done is to tap a short length of pipe into the lower part of the bearing, plugging the bottom end with a cap. Such a device has an added advantage in that it also acts as a dirt collector.

It is apparent that oil which is carried to the top of a ring-oiled bearing must be taken care of and returned to the reservoir as rapidly as it is delivered by the ring. If this is not possible, oil will tend to accumulate in the upper part of the housing to ultimately be forced out through the ends of the bearings.



Courtesy of Westinghouse Electric & Mfg. Company.

Fig. 17—A sealed-sleeve ring oiled bearing, the construction of which prevents the entry of air, dust, etc., and any possible escape of oil.

The same condition may arise if the oil is

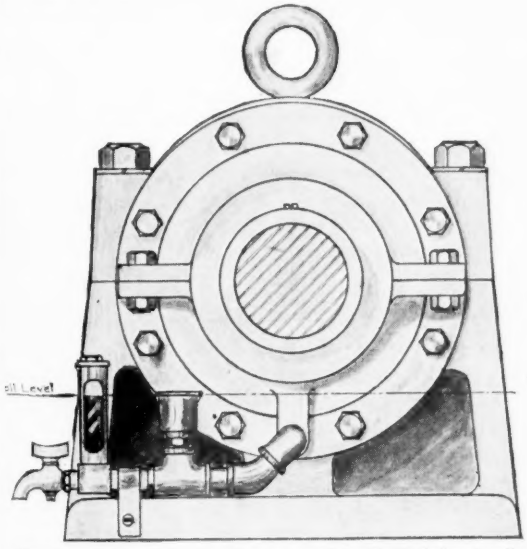
carried too high in the well, or if the ring rotates at too high a speed. This will cause a splashing and churning of the oil.

Therefore, the oil after being passed through the bearing, should be able to flow to the end or ends of the shaft and back to the oil reservoir below through a suitable return chamber which is part of the bearing housing.

Ring oiling affords a most efficient method of lubrication whereby the bearings are flooded with a considerable excess of oil over the amount that would theoretically be necessary to furnish the requisite oil film. By flooding a bearing with oil, the latter serves not only as a lubricant, but also as a cooling medium to carry away part of the frictional heat developed, thereby reducing the temperature of operation.

Lubricating systems of this nature possess natural advantages in that the flood of oil which is constantly passing through the bearings, tends to wash out any grit, dirt, dust or metallic particles that may have gained entry, as a result, reducing wear to a minimum.

On account of this washing action of the oil, however, the reservoir will gradually tend to accumulate a certain amount of sedimentary deposits. Therefore, it should be flushed out and cleaned at periodic intervals, the old oil being replaced with new or purified oil.

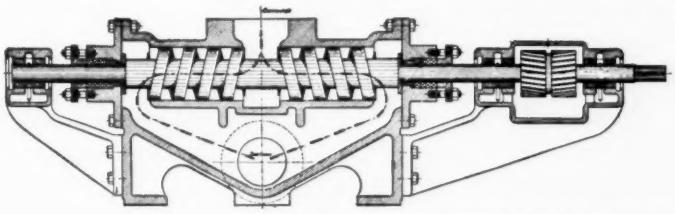


Courtesy of Aero Pulverizer Company and S. K. F. Industries, Inc.

Fig. 18—End view of a unit pulverizer bearing equipped with self-aligning roller bearings. Note gage glass, overflow and drain cock located at lower part of bearing. Oil level is shown by dotted line.

Oil Characteristics

To best effect lubrication by means of ring oilers, under normal temperature conditions it is essential to use a high grade straight mineral oil of approximately 150 to 200 seconds Saybolt at 100° F. In determining upon the viscosity of such an oil, the bearing construction should be investigated; oftentimes if oil returns are too small they may become clogged, causing heavier oils to overflow.



Courtesy of Wm. E. Quimby, Inc.

Fig. 19—Sectional view of a standard type screw pump. Note bearing brackets fastened to pump cylinder to decrease the possibility of misalignment. Bearings are ring-oiled.

By virtue of the fact that certain equipment may frequently be called upon to function under abnormally low temperatures, an oil with a low cold test should be chosen wherever possible. If this latter approximates zero degrees F. the oil will generally function satisfactorily.

On the other hand, higher temperatures will oftentimes require additional viscosity to resist the thinning down action of heat. Under such conditions, an oil of from 300 to 400 seconds viscosity or even higher may be advisable.

Anti-Friction Bearings

Where ball or roller bearings serve to support the journals of fans, rotors or impellers, etc., the matter of flood lubrication is eliminated. Prevention of corrosion in such bearings, is regarded by many as perhaps the chief function of the lubricant, rather than actual reduction of friction or removal of heat.

Anti-friction bearings have been extensively adopted by power plant equipment builders where certain requirements such as reduction in the amount of attention from a lubricating point of view, and positiveness of action must be observed.

Ball bearings can be lubricated either with oil or light grease according to the design of the bearing housings. Roller bearings can be similarly lubricated though the type and construction of the rollers must be considered in addition. The customary housing design in general affords ideal protection against the entry of contaminating foreign matter, and the least amount of oil or grease is required for refilling.

From a constructional point of view anti-friction bearings involve rolling contact as compared with plain bearings wherein sliding

contact occurs. In ball bearings, this rolling contact is that of a theoretical point over a given surface. Roller bearings, however, involve theoretical line contact between the journal or shaft element and the outer raceway.

Purpose of Lubrication

The purpose of lubrication is to facilitate as easy rolling as possible. To enable this, however, all the surfaces (which are of a highly polished nature) must be in as perfect condition as practicable. The lubricant must therefore serve the dual purpose of both lubricating, and protecting these surfaces against rusting, corrosion, pitting or abnormal wear.

Minimum clearance of course is an aid to proper functioning of such bearings, for the occurrence of any play between the component parts would tend to set up a certain amount of pounding which would be detrimental to effective operation. In other words, all motion must be as nearly akin to perfect rolling as possible.

Viscosity Requirements

As a general rule as light a lubricant should be used as can be successfully retained in such a bearing commensurate, of course, with the temperatures and pressures involved. Usually an oil with a viscosity of from 100 to 200 seconds Saybolt at 100° F., will be best.

To reduce the possibility of the development of abnormal internal friction within the lubricant, it is generally advisable to pay careful attention to the oil level. Certain authorities contend that submergence of approximately one-half to three-quarters of the lowest rolling element will be sufficient.

In this connection it is important to remember that contrary to the principles of plain bearing lubrication, the oil in a ball or roller bearing plays no part as a coolant. Therefore volume is a detriment rather than an advantage.

Roller bearing lubrication by means of oil is subject to much the same conditions as stated in connection with ball bearings. Where end thrust may develop to an appreciable extent, however, due to difficulty in keeping the rollers in alignment, or where pressures or temperatures may be high it is the opinion of certain authorities that it will be conducive to better lubrication if somewhat heavier oils are used.

Under such conditions straight mineral lubricating oils of as high as 750 seconds Saybolt viscosity at 100° F. are advocated. Even mineral cylinder oils of a high degree of purity may be necessary under conditions of extremely high duty, pressure or temperature.

The selection of heavier oils for roller bearing lubrication, however, should be carried out with the utmost care for it is very possible to over-estimate the conditions of operation with the result that an excess of internal friction may be developed. As a rule careful observation of bearing temperatures, and cooperation with the builder and oil industry will insure satisfactory results.

Grease Lubrication

Wherever there is possibility of oil leakage however, or under conditions of dust, dirt or dampness it may be advisable to resort to grease as the lubricant. Greases furnish better seals against the entry of dust, dirt and moisture thereby serving to protect the polished surfaces of the bearing elements in a very satisfactory manner. Grease also can be very much more effectively retained in a non-oil-tight housing; on the other hand, dirt or grit that finds its way into a grease lubricated bearing, has no means of settling out, but is frequently held in suspension, being carried back into the bearing repeatedly.

As a general rule soap-thickened oils which are comparatively fluid in consistency will meet average operating conditions where the lubricant must readily cover the entire surfaces of the balls or rollers and not tend to channel in the housings or raceways, as might occur with more viscous products of this nature which would have less of a penetrative ability.

On the other hand, under conditions of extra high temperature, it might be necessary to resort to greases of greater body to withstand the thinning-out effects of heat, and prevent the consequent entry of dust, dirt, or other contaminating foreign matter.

Other Means of Lubrication

All such bearings, however, will not always require or be equipped with ring oilers or anti-friction bearings. In certain cases grease cups, pressure gun fittings or sight feed oiling devices may be regarded as suitable by the builders, especially where operation is to be more or less intermittent. For such service a medium bodied engine oil or plastic grade of compression cup grease will in general be found satisfactory and economical.

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